Biaxial Nematic Liquid Crystal Phase in Bent Core Mesogens

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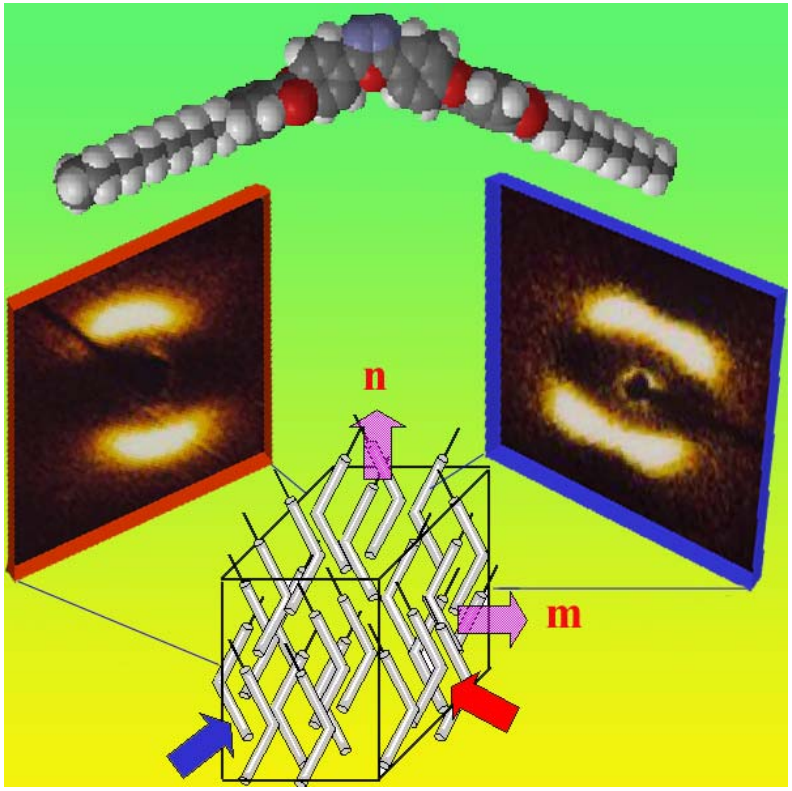
DMR-03-12792 and 87-20147

The electro-optically responsive fluid behind the flat screen displays is the *Nematic (N) Liquid Crystal*. It is composed of rod like molecules with long range orientational order and uniaxial symmetry along the direction **n** (known as the director) parallel to the long molecular axis about which the optical properties possess cylindrical symmetry. In 1970, the *biaxial* nematic phase was predicted with two orthogonal directors (or, optic axes), **n** and **m**. This phase had been found only in complex micellar solutions of surfactants with little technological utility. Past attempts to synthesize materials likely to exhibit this phase in single molecule systems did not succeed. Our work has lead to the discovery [1,2] of the biaxial nematic phase in thermotropic bent-core mesogens.

1. *Pramana* **61**, 231(2003).
2. *Phys. Rev. Lett.* **92** 145506 (2004).



The molecular structure of bent core mesogens (top) and their *biaxial* packing (box). Small angle x-ray diffraction patterns (panels) observed for two orthogonal directions (blue and red arrows) of incidence of x-ray beam, confirm their biaxial structure.

- The biaxial nematic phase has been one of the most sought liquid crysatal (LC) after phase in the past three decades. Many attempts have been made in the past but found to be invalid. This work resulted in the discovery of this phase that has already been independently confirmed by NMR measurements. Our paper was published in the Physical Review Letters. It was considered news worthy enough that Nature had this work featured in a News and Views article in which Prof. Luckhurst (Univ. of Southampton, UK) comments “It seems that a Holy Grail of liquid-crystal science has at last been found.”

- The work was performed by two graduate students who are currently pursuing research careers.

- This discovery and expected avalanche of new materials and studies that is soon to follow is highly likely to reveal new secrets of the nature. These materials will prove to be test-beds for the scientific ideas and theories.

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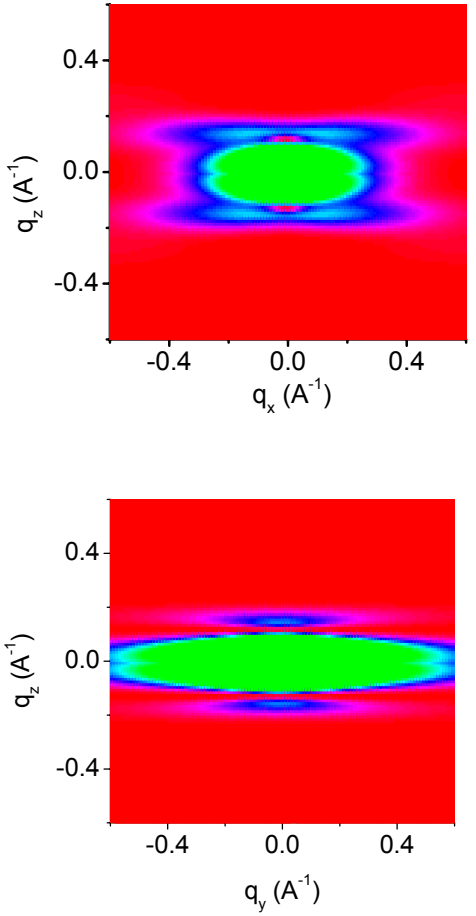
Scientific &Technological Impact:

This discovery has generated considerable interest in these materials as testing grounds for theoretical concepts and predictions. Molecules in the biaxial N phase can spin much faster about their long axis and change the orientation of **m** than the reorientation of **n** currently exploited in commercial displays. Technologically, this *biaxial* elecro-optical response related to changes in **m** is expected to be ~100 times faster than conventional devices. The biaxial nematic liquid crystals are expected to lead to a new generation of displays and photonic devices.

Education:

Drs. Bharat R. Acharya and Andrew Primak, performed this research as graduate students. They are currently pursuing their careers at Platypus Technologies, Madison, WI and Mayo Clinic, Rochester, MN, respectively.



The calculated x-ray diffraction intensity in **m-n** plane (top) and in an orthogonal plane containing **n** (bottom) in reciprocal space, in complete quantitative agreement with experimental results.

- The technological significance of these materials was recognized even before their discovery. The ability of the LC molecules to spin about their long axis at a rate much faster than to “tumble” and reorient their long axis in response to an applied field makes them very attractive for electrooptical (such as flat panel displays) and photonic applications. Being biaxial, they are likely to be exploited in retardation films to eliminate leakage of light at 45 degrees in LC displays. Presently, films prepared with very cumbersome processes are being used.

- Our work has already revealed their fast switching properties and we are beginning to receive enquiries from display industry asking more details about them.

- To summarize, their discovery will lead to new chemical synthesis, physical studies of their properties and numerous important applications.